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Training and Tactical ORS Operations (TATOO)

Robert Strunce, Thomas Mann
Star Technologies Corporation

Barbara Sorensen
AFRL (HE)

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TRAINING AND TACTICAL ORS OPERATIONS (TATOO)

Robert Strunce, President, Star Technologies Inc, Great Falls VA
Dr. Barbara Sorensen, AFRL (HE), Mesa AZ
Thomas Mann, Project Manager, Star Technologies Inc, Great Falls VA

ABSTRACT

Star Technologies Corporation is developing a "Training and Tactical ORS Operations" (TATOO) Classroom/Laboratory under the direction of the Air Force Research Laboratory / Human Effectiveness (AFRL/HE) Division. This paper will discuss the laboratory hardware and software being created to give voice to the Warfighter's interaction with Operationally Responsive Space (ORS) satellites. The goal of the TATOO laboratory is to provide an environment for the development of procedures and protocol for tasking tactical satellites as well as an environment for training the Warfighter on the tasking process.

ORS systems aim to provide operational space capabilities, flexibility and responsiveness to the theater that do not exist today. ORS communication, navigation and ISR (Intelligence, Surveillance, and Reconnaissance) satellites are designed to replace or supplement existing systems in order to enhance the current space force. They intend to rapidly meet near term space needs of the tactical forces. The ORS concept includes new tactical satellites specifically designed to support contingency operations such as increased communication bandwidth, and ISR imagery over the theater for a limited period to support air, ground, and naval force missions. The full potential of ORS is to support in-theater tactical forces to develop satellite tasking, data retrieval and interface capabilities for mission operations from a Warfighter centered perspective, and to develop realistic training and simulation that allows development, demonstration, and assessment of ORS tactical CONOPS (Concept of Operations).

The TATOO Objectives are to support in-theater commanders & Warfighters by revising and exercising the Operationally Responsive Space mission CONOPS for in-theater tasking, scheduling, interface and data retrieval for tactical satellites. TATOO provides a laboratory/classroom environment for the development, testing, and evaluation of ORS Tactical Mission CONOPS for in-theater ORS operations to:

- Develop a user interface and protocol for the easy tasking of ORS Satellites.
- Emulate major in-theater satellite mission control components including-Tactical Ground Stations, Tactical Mission Tasking Operations, & Warfighter support systems.
- Emulate in-theater communications with local area network to provide connectivity.
- Simulate tactical satellite operations, dynamics, and data collection with Spacecraft Design Tool.

The potential TATOO benefits are

- Develop training materials and a process for the tasking of ORS Satellites by the Warfighter.
- Working with the Warfighter to ensure that their needs are met.
- Support the ability to rapidly design, fabricate, test and launch a responsive tactical satellite within a six day window.
- Provide realistic training and simulation capabilities that will allow development, demonstration, and assessment of ORS tactical CONOPS.
- Allow distributed mission teams to interact in day-to-day satellite operational control through VMOC (Virtual Mission Operations Center).
- Support the operational side of ORS and merge with the revolutionary ORS spacecraft development and deployment processes to make the ORS paradigm a reality.
- Enable in-theater interactive training exercises that promote training of in-theater personnel.

INTRODUCTION

This paper will discuss the TATOO Lab, a computer-based simulation environment (Figure 1: The TATOO Laboratory) being built at Star Technologies' Great Falls, VA facility. The purpose of the TATOO Lab is to assist in developing an ORS CONOPS, to exercise and optimize the ORS CONOPS, and to train Warfighters and support personnel in ORS tactical satellite tasking and operations. Training is usually an afterthought, and the TATOO Lab attempts to put focus on the Warfighter, the Warfighter's needs (under ORS), and the training materials for the Warfighter before ORS becomes a reality.

The TATOO Lab will allow users to exercise training scenarios to demonstrate how ORS satellites can quickly assist in mission needs.

Users of the lab will use Star Technologies developed software to task space assets and to monitor satellite health and status. Delays that emulate communication transmissions will be modeled to illustrate bottlenecks. The effect of changes in the ORS CONOPS can be demonstrated in the lab, and operational enhancements that are discovered in the lab can, in turn, be used to refine and redefine the ORS CONOPS.

Figure 1: The TATOO Laboratory

The TATOO lab includes the software necessary to emulate aspects of proposed ORS operations, from the Warfighter applications to satellites. The lab is designed to train both the Warfighter and spacecraft operator, fostering an environment where a standard operational approach can be developed to benefit both the Warfighter and operator.

TATOO LAB USERS AND COMPONENTS

The TATOO Lab is being designed to accommodate several groups of users. The Warfighter and theater commander represent the theater node. Software at this node includes ESRI's ArcView programs, FalconView, and the Satellite Tasking Manager plug-in (described later in this paper). In the case of TATOO, the Warfighter is a member of Special Operations Forces and we envision that they would undergo certification before gaining access to the tools to task directly. Special Ops would need situational awareness capabilities in remote locations where traditional communications methods might not exist.

The satellite emulation node contains the ORS satellite(s) as modeled by Star Technologies' Spacecraft Design Tool (SDT). For different training exercises, the satellites can operate at realtime or significantly faster.

Satellite Systems Operators (SSO) are the users at the VMOC node. The number of ORS satellites can be dynamically changed to allow experimentation with constellation size and the resulting effects on the timeliness on meeting battlefield requests. AGI's STK with coverage module is used for the SSOs to experiment with different orbits to prepare for the launch of a new ORS satellite. New orbital information can be published to SDT from STK.

The Reachback node contains the Image Product Library (IPL), the repository of images saved from ORS Satellite collections. Personnel at this node include imagery analysts whose expertise can be called upon by the theater or VMOC nodes. Analysts can annotate imagery and publish it to the IPL so that the theater can access it.

Each node can broadcast its video output to any combination of eight 45" high definition LCD TVs. Prewired ports for video and network access and wireless allow for future expansion.

ORS SATELLITE SIMULATION WITH SDT

The Satellites are emulated with Spacecraft Design Tool (SDT), a high fidelity spacecraft 6 degree-of-freedom (6DOF) simulation tool developed by Star Technologies, Inc. SDT (Figure 2: Spacecraft Design Tool) is based on Microsoft's .NET framework, thereby providing true software plug-and-play components.

The modeled satellites are addressable individually via a TCP/IP port. Each contains an Activity Manager; a mechanism to reconcile Warfighter requests with battery charging and other autonomous state-of-heath activities. An on-board Targeting component is responsible for organizing the requests and developing a slewing approach[1].

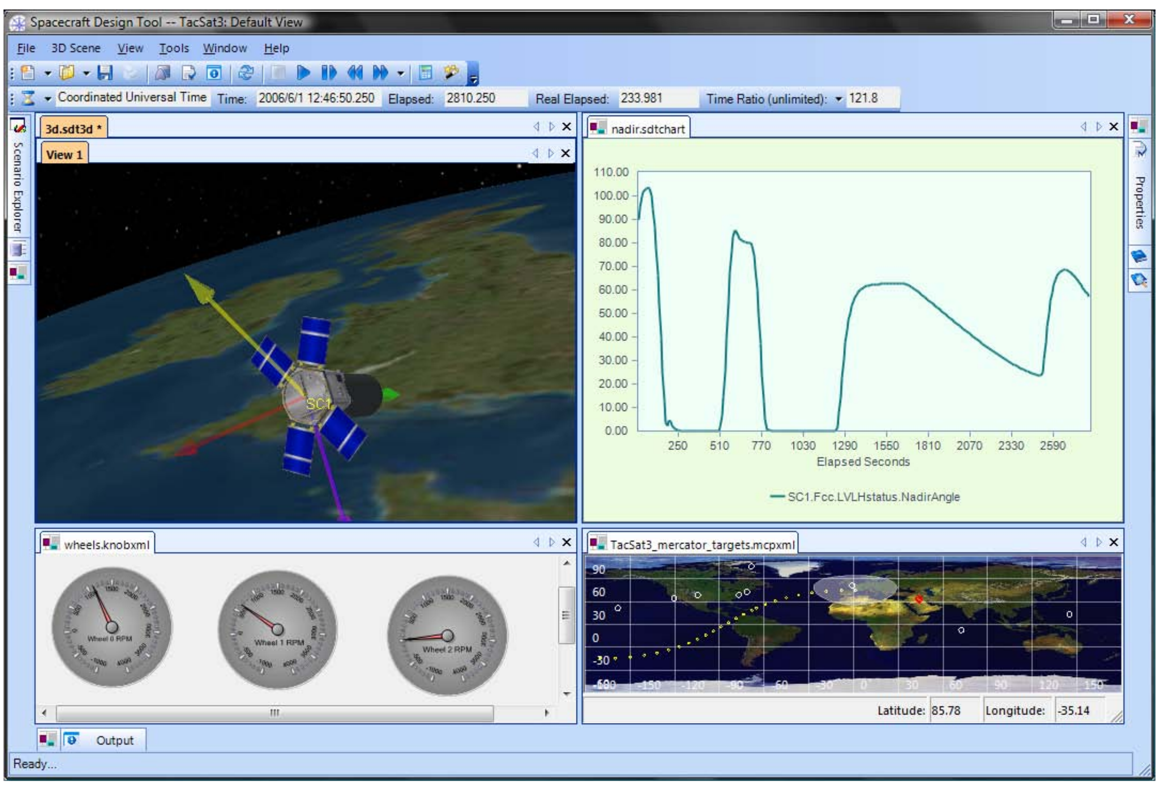

Figure 2: Spacecraft Design Tool

SDT is the software application that provides an open framework for Responsive Space's rapid design concept spanning mission capture to deployment. SDT is the core 6DOF high- fidelity simulation currently in the AFRL's Responsive Space Test Bed. SDT is integrated into the Mission Design phase and the real time HITL test cells and it provides an environment for rapid prototyping of spacecraft using true software Plug-n-Play of components, environment and subsystems[2].

SATELLITE/WARFIGHTER COMMUNICATION

We are researching two ways for Warfighters to directly communicate with ORS satellites: by RF and SIPRNet.

The first approach is with the PRC-117 military radio. This method is how Star Technologies is proceeding in AFRL's Plug-n-Play satellite effort. In this case, a Warfighter can send tasking requests directly to the satellite and receive products directly via a 9600bps downlink stream. The RF downlink speed limits the type of products available to the Warfighter, but text-based, lightweight information is feasible. Image processing algorithms envisioned for AFRL's Plug and Play satellite effort and possible with High Performance On Orbit Computing (HPOOC) can generate these messages that can be interpreted by the Warfighter's software. Larger data can be broken up and received from different ORS satellites at different times. Expected data transmission times, errors, and retries are emulated via components built into SDT.

The SIPRNet approach assumes that a satellite is a node on the SIPRNet addressable with TCP/IP and that the Warfighter has SIPRNet access. Satellite products can be returned to him almost instantly after a collection occurs, and the high downlink speed increases the scope of products available. We recognize that this approach is possibly not-feasible with today's technology, but should be considered for the future.

It is also possible that a Warfighter might request satellite support by sending a request to the JTAC (Joint Terminal Attack Controller). Star Technologies is working with Air Force Special Operations Command to create a training methodology for JTACS for ORS Satellite tasking.

ORS SERVICE

To support the concept of direct tasking by in-theater Warfighters, there is a need for an ORS Service. The ORS Service would run in a distributed fashion on-board each satellite in the ORS constellation, maintaining information about each satellite and determining which satellite is best suited to fulfill a tasking request. The ORS Service would maintain information such as position, attitude, slew rates, expected housekeeping times, as well as availability. This information would be sent to the ground terminal – the Satellite Tasking Manager (see the next section), effectively sending almanac data.

Tasking can be accomplished by using the ORS Service as a "broker": tasking can be sent in advance to any satellite in the constellation, and the ORS Service would determine which satellite would be tasked.

SATELLITE TASKING MANAGER (STM)

The Satellite Tasking Manager (STM) is software that enables the Warfighter to task a satellite by using a point and click interface. STM is constructed as a plug-in and can be accessed by a toolbar button in ArcMap and FalconView. STM interfaces with the selection, drawing, and annotation capabilities in both tools.

Working with the ORS Service, STM displays a projected ground trace of each ORS satellite over a location with their expected pass time, current tasking load, and capabilities. This data is updated on an as-needed basis when STM connects with the ORS Service, and kept fresh using a propagator. Using this information, the Warfighter can point and click to task a specific satellite.

STM allows a user to select an area of interest on a map, resulting in a coordinate set corresponding to an area. Additional constraints such as date, time of day, look angle, and cloud cover can also be entered.

Those satellites that cannot meet the Warfighter's constraints are identified. The exact interface will evolve with user testing.

When multiple Warfighters send tasking requests to a set of ORS satellites, conflicts due to overlapping tasking requests will inevitably occur. Through STM, a Warfighter has the capability to change constraints and delete tasking requests. If Warfighters themselves cannot resolve their conflicting requests, the request can be published to a commander who can view the requests and approve one or the other. Additionally, a commander can authorize a Warfighter to have complete control for a given time period.

If any satellite in the ORS Constellation has on-board image processing algorithms, dialogs in STM enable the Warfighter to select features that the algorithms could detect.

Once a task is prepared, the request to the satellite can be directed through RF or a SIPRNet connection (both connections are emulated in the lab). A task is sent to the ORS Service and loaded on a specific Satellite's Activity Manager. The TATOO Lab will experiment with different tasking procedures in order to determine what limitations are placed on the Warfighter.

Figure 3 gives an overview of direct tasking as envisioned in the TATOO Lab.

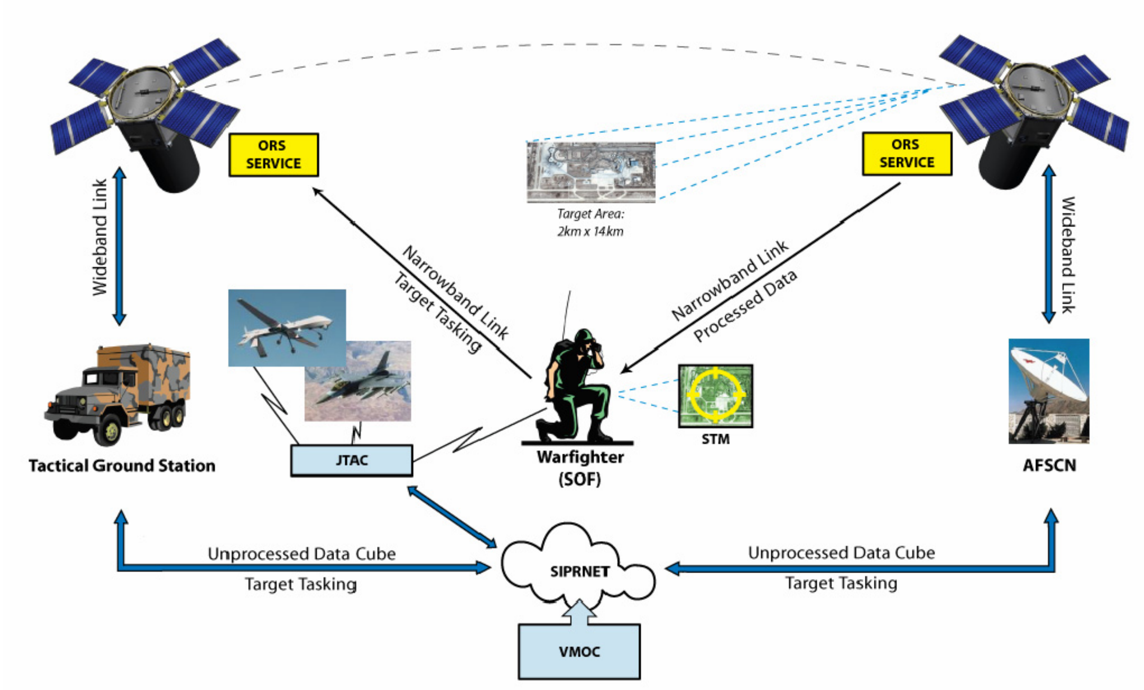

Figure 3: Tasking Overview

TATOO TRAINING EXERCISES

To illustrate how the components of the TATOO Lab work together, we are creating training exercises. A typical exercise shows how ORS ideas can streamline and optimize the process of requesting satellite products, with the end goal of getting information to the Warfighter quicker. Exercises are stored in a web-based courseware program and are accessible in the TATOO Lab. Each exercise is broken down into a series of screens and organized by role. They are played on one of the screens in the TATOO Lab like a slideshow, and display the actions that are needed at any point in time.

One example is “Bomb Damage Assessment”. In this exercise, a Warfighter requests information to ensure that a facility and access to the facility has been damaged beyond easy repair. It is assumed that the Warfighter already has existing maps and imagery of the area. Accessing the Satellite Tasking Manager (an icon in the ArcMap or FalconView toolbar), the Warfighter gets access to drawing tools and can select the area of interest, constraints, and also what types of objects that should be identified by the on-board image processing algorithms. An example would be to highlight any bridges that are no longer usable. As a result of a previous synching with the ORS Service and STM’s built-in propagator, STM displays a current position of each satellite in the ORS Constellation. The task is turned into a message that can be transmitted directly to the satellite using a PRC-117 military radio. The satellite sends text-based messages directly to the Warfighter that are interpreted by STM. The messages create symbols and are drawn on the Warfighter’s existing maps using FalconView and ArcMap’s built-in drawing tools.

Receiving imagery is also possible, but due to the 9600bps transmission limit, the imagery product would probably have to be received in multiple tries, and pieced together with STM.

If SIPRNet access exists for both the tasking and the product retrieval, the satellite product could be high-resolution imagery and received immediately after a collection. The Warfighter can then compare it against his existing image library. If needed, he can initiate reachback through VMOC to request an Imagery Analyst’s assistance.

CONCLUSION

The TATOO Laboratory provides a flexible environment for the development of unique Warfighter CONOPS. TATOO can rapidly prototype multiple satellites and their respective constellation using SDT to simulate a variety of ORS tactical satellite scenarios. TATOO provides the training and simulation capability necessary to certify the Warfighter in direct tasking of tactical satellites.

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